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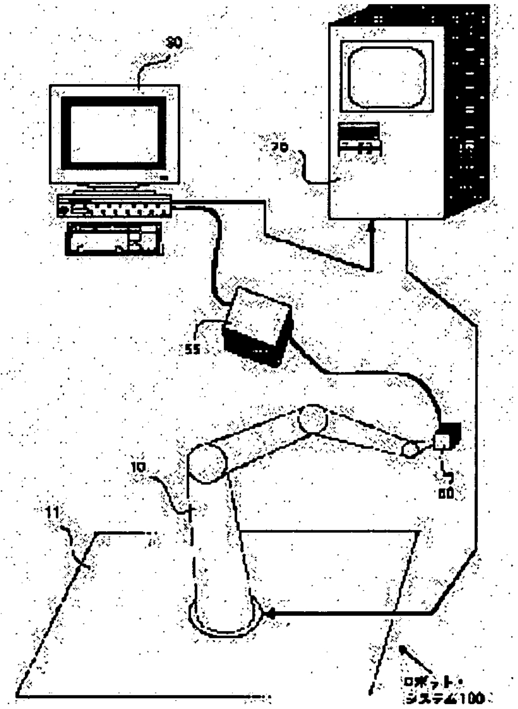
(54) ARTICULATED ROBOT SYSTEM WITH FUNCTION OF MEASURING ATTITUDE, METHOD AND SYSTEM FOR CERTIFYING MEASURING PRECISION OF GYRO BY USE OF TURNTABLE FOR CALIBRATION REFERENCE, AND DEVICE AND METHOD FOR CALIBRATING TURNTABLE FORMED OF N-AXES

(57)Abstract:

PROBLEM TO BE SOLVED: To realize a real-time, non-contact, and highly precise attitude measurement free from limitation of measuring range by arranging a piezoelectric rotary gyro at the fingertip of a robot.
SOLUTION: An articulated robot system 100 is provided with a piezoelectric element rotary gyro 50 which consists of, for example, two gyro units each consisting of two sets of piezoelectric element-made benders and detects the angular velocity around three axes and acceleration in three axial directions of the fingertip of a robot 10. The detected angle speed is arithmetically processed by a signal processing box 55, whereby the attitude change from the initial attitude can be determined. The static and dynamic precision certification with the assumption of the natural movement of the robot with respect to the gyro



50 is performed, for example, by use of a turntable with three degrees of freedom as calibration reference, and a laser tracking system, for example, is used for the calibration of dimensional error or mounting error of the turntable itself.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]
[Claim 1] In a multi-articulated-robot system with the function which measures a posture The arm beyond (a)2, The articulated robot which consists of a shaft supported for between each arm, enabling free rotation, and two or more mechanical components which carry out the rotation drive of each shaft of the (b) aforementioned robot, (c) The piezoelectric-device rotation mold gyroscope arranged by said robot's abbreviation point, (d) The drive control section which controls the drive of each of said mechanical component according to a command value, (e) Multi-articulated-robot system characterized by providing the measurement section which measures said robot's posture according to the output of said piezoelectric-device rotation mold gyroscope while said mechanical component drives said robot.
[Claim 2] The 1st phase of being the approach of using a turntable for a calibration standard and verifying the measurement precision of a gyroscope, and performing the calibration about the own dimension error of the (a) aforementioned turntable and the installation error of said gyroscope, (b) The 2nd phase which creates the order kinematics model which computes the theoretical attitude angle (a roll, a pitch, yaw angle) which said gyroscope takes from angle of rotation of each shaft of said turntable, (c) How to use for a calibration standard the turntable characterized by providing the 3rd phase of verifying the measurement precision of said gyroscope by comparing with the actual output value from said gyroscope each attitude angle acquired from an order kinematics model, and to verify the measurement precision of a gyroscope.
[Claim 3] How to use for a calibration standard the turntable according to claim 2 characterized by performing a calibration in said 1st phase using the measuring device formed in said TAN table exterior, and to verify the measurement precision of a gyroscope.
[Claim 4] How to verify the measurement precision of the piezoelectric-device rotation mold gyroscope of three degrees of freedom which are the approaches of verifying the measurement precision of the piezoelectric-device rotation mold gyroscope of three degrees of freedom, and are characterized by using the turntable of three or more degrees of freedom.
[Claim 5] The turntable which is the system which verifies the measurement precision of a gyroscope and is used as a (a) calibration standard, (b) 1st means to perform the calibration about the dimension error of a turntable own [said] and the installation error of said gyroscope, (c) 2nd means to create the order kinematics model which computes the theoretical attitude angle (a roll, a pitch, yaw angle) which said gyroscope takes from angle of rotation of each shaft of said turntable, (d) System which verifies the measurement precision of the gyroscope characterized by providing 3rd means to verify the measurement precision of said gyroscope by comparing with the actual output value from said gyroscope each attitude angle acquired from an order kinematics model.
[Claim 6] Said turntable is a system which verifies the measurement precision of the gyroscope according to claim 5 characterized by having three or more degrees of freedom.
[Claim 7] Said 1st means is a system which uses for a calibration standard the turntable according to claim 5 characterized by performing a calibration using the measuring device formed in said turntable exterior, and verifies the measurement precision of a gyroscope.

[Claim 8] In the equipment which performs the calibration of the turntable which consists of N shafts (a) The specimen arranged in the abbreviation periphery edge of a turntable, and a means to pursue said specimen and to measure the location of the multipoint on the orbit while driving each shaft of the (b) turntable, (c) Equipment which performs the calibration of the turntable which consists of N shafts characterized by including a means to identify the rotating shaft, based on the location of the measured multipoint.
[Claim 9] Equipment which performs the calibration of the turntable which consists of N shafts according to claim 8 characterized by installing said specimen in the abbreviation tip edge of said fixture while installing the fixture of a longitudinal configuration in radial [of a turntable].
[Claim 10] In the approach of performing the calibration of the turntable which consists of N shafts (a) The phase which arranges the specimen in the abbreviation periphery edge of a turntable, and the phase of driving one of the shafts of the (b) turntable, (c) The phase which pursues said specimen and measures the location of the multipoint on the orbit while driving the shaft of a turntable, (d) How to perform the calibration of the turntable characterized by constituting including the phase of identifying the rotating shaft, based on the location of the measured multipoint from an N shaft.
[Claim 11] Said phase (a) is the approach of performing the calibration of the turntable which consists of N shafts according to claim 10 characterized by including installing said specimen in the abbreviation tip edge of said fixture while installing the fixture of a longitudinal configuration in radial [of a turntable].

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing having shown typically the configuration of the robot system 100 concerning this example.
[Drawing 2] It is drawing having shown the structure of the piezoelectric-device rotation mold gyroscope 50.
[Drawing 3] The structure of the gyroscope unit 51 is illustrated.
[Drawing 4] It is drawing having shown signs that the gyroscope system of coordinates alpha, beta, and gamma were defined on the basis of the base and side face of a case of the piezoelectric-device rotation mold gyroscope 50.
[Drawing 5] It is drawing having shown the roll phi defined with the relative-position relation between gyroscope system-of-coordinates ****gamma and the world coordinate system XYZ, the pitch theta, and the yaw angle psi.
[Drawing 6] It is drawing having shown a general view of 3 degree-of-freedom turntable 200.
[Drawing 7] It is drawing having shown the outline configuration of the laser tracking system made from Leica (form: SMART310).
[Drawing 8] It is drawing having shown DH modeling used by this example.
[Drawing 9] It is drawing having shown the correction DH modeling used by this example.
[Drawing 10] It is drawing having shown the outline which calculates the link parameter between the 3rd axial seat label systems from measurement system of coordinates.
[Drawing 11] It is drawing having shown the device parameter about the installation error of a gyroscope.
[Drawing 12] It is drawing having shown typically signs that posture conversion was carried out in the gyroscope system of coordinates in an initial posture from the gyroscope system of coordinates after turntable 200 rotation.
[Drawing 13] It is the graph which showed the static-accuracy verification result of a gyroscope 50, and, more specifically, is the graph which plotted each of the theoretical value of the output include angle of a gyroscope 50, and an experimental value.
[Drawing 14] It is the graph which showed the dynamic-accuracy verification result of a gyroscope 50, and, more specifically, is the graph which plotted the detection result of the roll angle at the time of a step response.
[Drawing 15] It is the graph which showed the dynamic-accuracy verification result of a gyroscope 50, and, more specifically, is the graph which plotted the detection result of the roll angle at the time of a frequency response.
[Description of Notations]
10 -- Robot body
20 -- Robot controller,
30 -- Computer system,
50 -- Piezoelectric-device rotation mold gyroscope,

51 52 -- Cylinder mold gyroscope unit,
51a, 51b -- Vendor made from a piezoelectric device,
55 -- Signal-processing box,
100 -- Robot system,
200 -- 3 degree-of-freedom turntable,
201,202 -- Arm,
203 -- Cat's-eye,
204 -- Counter weight,
210 -- Table,
211 -- The 1st motor of a turntable,
212 -- The 2nd motor of a turntable,
213 -- The 3rd motor of a turntable,
300 -- Laser tracking system,
301 -- Laser interferometer
302 -- Tracking mirror.

[Translation done.]

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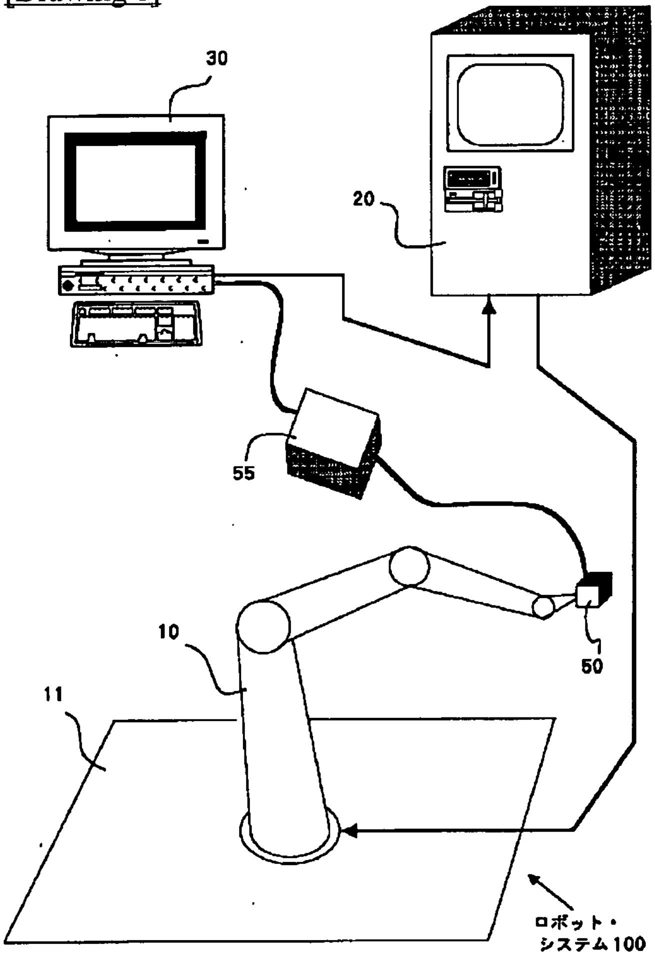
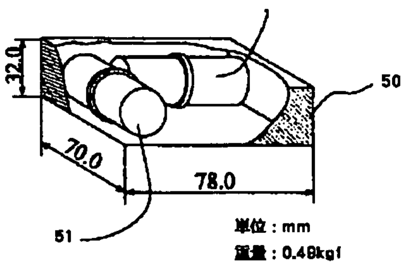
DRAWINGS

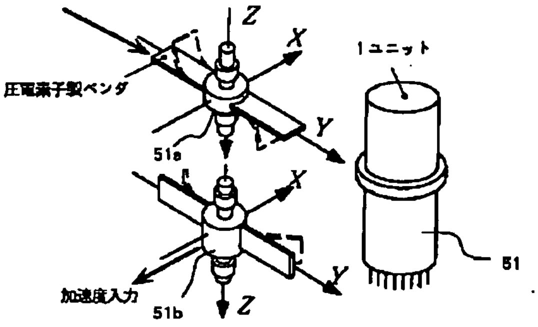
[Drawing 1]


30
20
55
10
50
11
ロボット・システム100

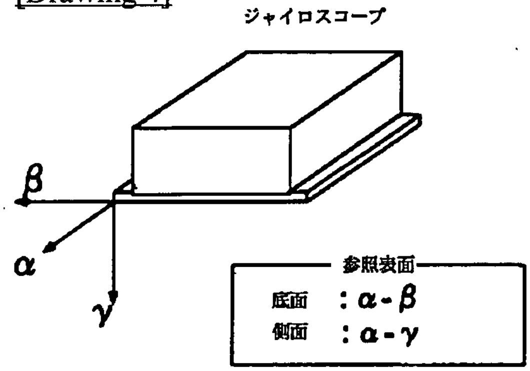
[Drawing 2]


52
50
32.0
70.0
78.0
51
単位：mm
重量：0.48kgf

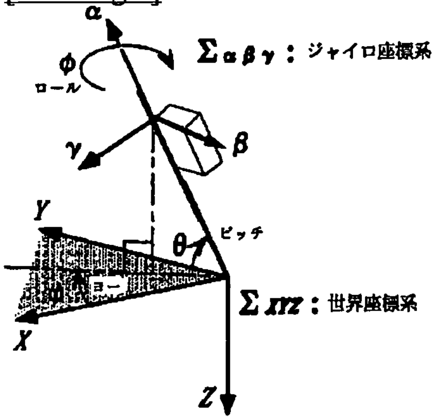
[Drawing 3]


角速度入力
Z
X
1ユニット
圧電素子製ベンダ
Y
51a
X
51
Y
加速度入力
51b
Z

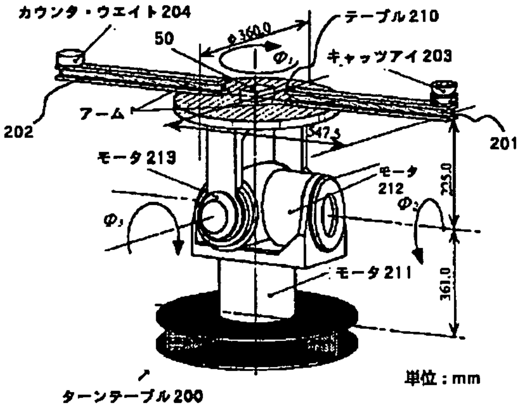
[Drawing 4]


ジャイロスコープ
β
α
γ
参照表面
底面 : α-β
側面 : α-γ

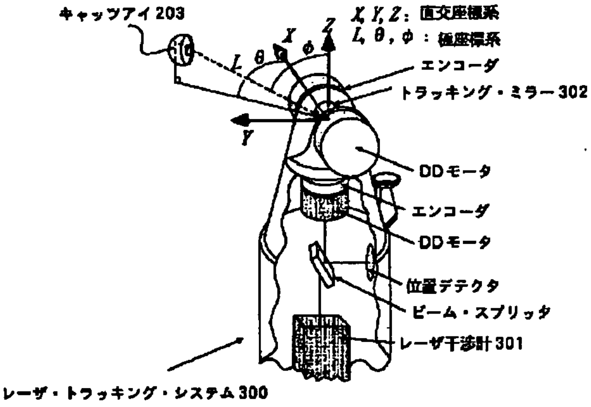
[Drawing 5]


α
Σαβγ : ジャイロ座標系
φ
ロール
γ
β
Y
θ
ピッチ
ヨー
Σxyz : 世界座標系
X
Z

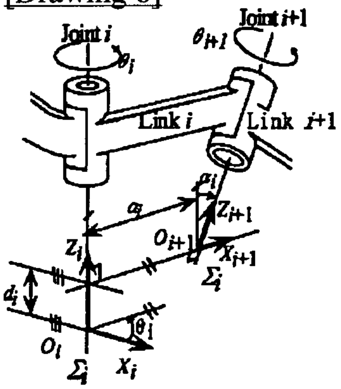
[Drawing 6]


カウンタ・ウエイト204
テーブル210
50
φ360.0
Φ1
キャッツアイ203
アーム
202
201
547.5
モータ213
モータ
212
Φ3
Φ2
225.0
モータ211
361.0
単位：mm
ターンテーブル200

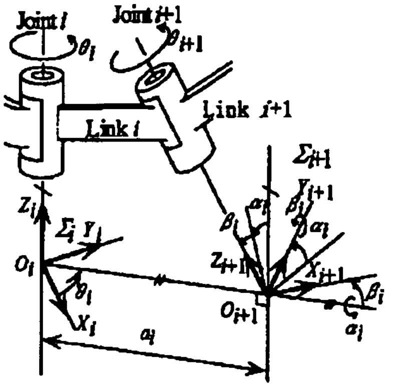
[Drawing 7]


キャッツアイ203
X, Y, Z：直交座標系
L, θ, φ：極座標系
X
Z
L
θ
φ
エンコーダ
トラッキング・ミラー302
Y
DDモータ
エンコーダ
DDモータ
位置デテクタ
ビーム・スプリッタ
レーザ干渉計301
レーザ・トラッキング・システム300

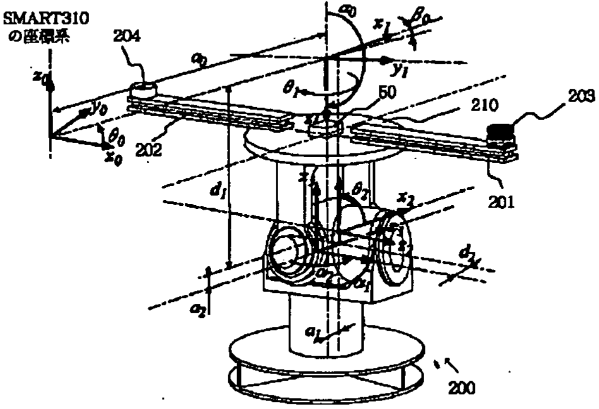
[Drawing 8]


Joint i
θ_i
θ_{i+1}
Joint i+1
Link i
Link i+1
a_i
α_i
Z_{i+1}
Z_i
O_{i+1}
X_{i+1}
Σ_i
d_i
θ_i
O_i
Σ_i
X_i

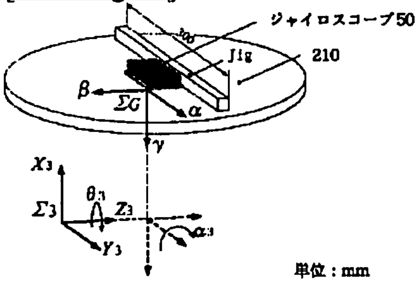
[Drawing 9]


Joint *i*
Joint *i*+1
θ_i
θ_{i+1}
Link *i*
Link *i*+1
Σ_{i+1}
Y_{i+1}
Z_i
Σ_i
Y_i
O_i
β_i
α_i
Z_{i+1}
X_{i+1}
θ_i
X_i
O_{i+1}
a_i

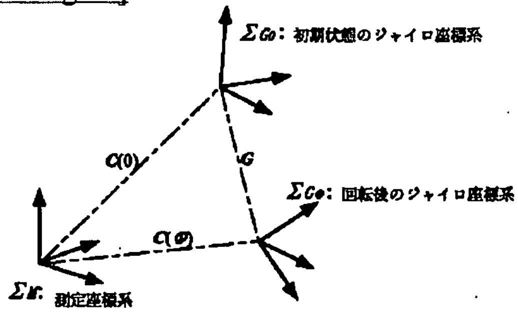
[Drawing 10]


SMART310
の座標系
204
a_0
α_0
x_1
β_0
y_1
θ_1
50
210
203
z_0
y_0
θ_0
x_0
202
d_1
z_1
θ_2
x_2
201
d_2
α_2
α_1
a_2
a_1
200

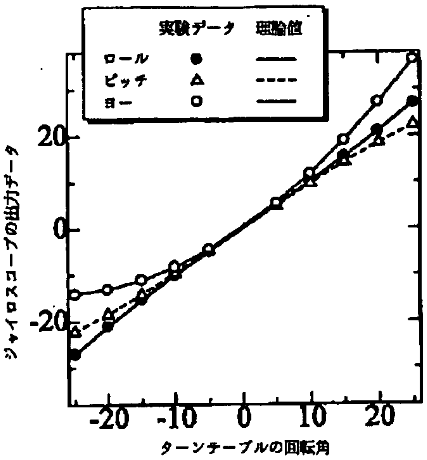
[Drawing 11]


ジャイロスコープ50
100
Jig
210
β
ΣG
α
γ
X_3
θ_3
Σ_3
Z_3
Y_3
α_3
単位：mm

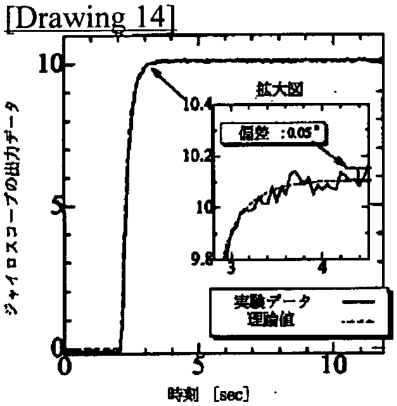
[Drawing 12]


Σ_{G0}: 初期状態のジャイロ座標系
C(0)
G
$\Sigma_{G\phi}$: 回転後のジャイロ座標系
C(φ)
Σ_K: 測定座標系

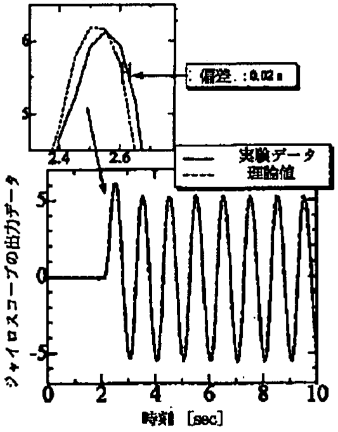
[Drawing 13]



[Drawing 14]



[Drawing 15]



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